

Pesticide Industry Regulation: Economic Consequences as Revealed through Stock Price Behavior

**Mark S. Johnson
Ron C. Mittelhammer
Don P. Blayney**

Previous studies of the economic consequences of regulation of the pesticide industry and their products have tended to focus upon agricultural commodity producers and consumers. This article examines stock price behavior by means of event study methodology in order to measure the impact of selected regulatory decisions on producers of pesticides in the United States. Several regulatory actions were found to have significant negative impacts on the US pesticide industry, ranging between 1.6% and 3.0% of shareholder value. The incidence of these effects depended on the type of regulation instituted and the circumstances surrounding the decision to change a regulation.
© 1992 John Wiley & Sons, Inc.

In the process of formulating regulations for pesticide production and use, the US Environmental Protection Agency (EPA) considers many factors, including the risks and benefits of chemicals.¹ Previous studies have examined the impact of pesticide regulations on one of the primary groups of users of pesticides, namely

The authors would like to thank Jon Freitag for assistance in data collection. Additionally, the authors would like to thank Doug Duncan and Craig Osteen for insightful comments on earlier drafts of this manuscript and two anonymous reviewers for their helpful and constructive comments.

The authors are Assistant Professor of Finance, University of Idaho, Professor of Agricultural Economics, Washington State University, and Agricultural Economist, USDA, ERS, respectively.

Agribusiness, Vol. 8, No. 4, 347-364 (1992)

© 1992 by John Wiley & Sons, Inc.

CCC 0742-4477/92/040347-18\$04.00

farmers, and on the consumers of agricultural products. This study examines the impact of selected regulations on pesticide producers in the United States. Agribusiness researchers, farmers, and consumers should be concerned about the impact of regulations on pesticide producers because the financial well-being of the industry can have important consequences regarding the future availability of products and their prices.

Measuring the impact of changes in government policies and regulations on sectors of the agribusiness industry has typically not utilized financial market data explicitly. This study utilizes common stock prices in the context of an event study to measure the effects of regulation on selected pesticide producers. This approach is widely used by corporate finance researchers and is generally accepted as a valid approach for measuring the impact of events on the value of publicly traded firms where the stocks are traded on efficient financial markets. Events are defined as any changes in the economic environment which may affect the firm's value through investor expectations about future risk and cash flows.

Previous event studies have examined a wide range of economic events. The majority of published studies focus on the impact of firm-specific events such as mergers and acquisitions, issuance of debt, and equity. Recently, several researchers have used the event study method to examine regulatory impacts. Examples include the impact of OSHA-imposed dust standards on textile firms, the impact of product recalls, the effects of the Bank Holding Company Act of 1970, deposit ceilings, merger regulations, and tobacco industry regulations.²⁻⁷

There are two major reasons that the impact of regulatory events on the value of pesticide firm equity should be measured. First, such measurement quantifies the effect on shareholder wealth in terms of returns on investment. Second, resource reallocation out of the pesticide industry may occur due to the impact on firm value. Such a resource reallocation could affect future availability of current or new products, the farmers' cost of producing commodities, and, ultimately, the cost of agricultural products to consumers. Reallocation of resources away from the firm occurs when capital budgeting is done to evaluate potential investment in new projects and events cause the net present value of such projects to be reduced. When these effects are industry-wide, capital will be allocated out of the industry.

Prior to 1970, few cancellations of agricultural chemicals occurred. The EPA was quite active in regulating the use and production of pesticides over the period 1970-1990. Therefore, several potentially important events are examined during the 1970-1990 period in order to provide evidence on the types of regulations that are likely to impact the industry and to gauge the magnitudes of such impacts.

THE EFFICIENT MARKET HYPOTHESIS AND EVENT MEASUREMENT

The event study approach assumes that the efficient market hypothesis (EMH) holds true for the stock markets upon which a firm's stock is traded. This hypothesis implies that stock prices will reflect all available information that influences the firm's risk and expected future cash flows. The price of a firm's stock, and thus the value of its equity as perceived by analysts and investors, is the discounted value of future cash flows. The discount rate is determined by the perceived riskiness of the firm. Therefore, changes in stock prices, and thus firm

value, reflect changes in expectations about future cash flows and risk. Because investors and analysts continually re-evaluate firm values, new information is quickly incorporated into stock prices.

A question that has been examined closely in the corporate finance literature is: "What information is quickly incorporated into stock prices?" At this point, most research indicates that stock markets in the United States are semi-strong form efficient.⁸ Such markets quickly reflect all publicly available information. Therefore, it would be expected that any publicly available information about regulation will be quickly incorporated into stock prices if the information changes investors' expectations regarding risk or future expected cash flows. Based on this observation, the event-study approach focuses upon stock price changes at and around the time information is released to the public, which constitutes an *event period*. Thus, it is crucial to any event study that the time at which information is released to the public be clearly identified.

Clear identification of the times at which information is released to the public is particularly difficult when examining the effects of regulation for two reasons. First, regulatory agencies often make multiple public announcements about possible regulations prior to a final decision regarding change in regulations. Second, information occasionally leaks to the public from inside the regulatory agency prior to official announcements. A detailed discussion of the rationale for event period choices in this study is presented in a subsequent section entitled "Analysis of Events."

Binder points out an additional aspect that is crucial to any event study; the determination of the effect which new information has on investor expectations.⁹ Specifically, investors expect a normal rate of return from holding a stock. These normal returns, in the form of dividends and capital gains, are dependent upon the state of the macroeconomy, the overall performance of the stock market, and the perceived risk of the firm. Thus, in an examination of the impact of regulation on firm value, it is inappropriate to simply calculate the market value of the firm's equity before and after the regulatory event and attribute all of the change in value to the regulatory event. The impact of a regulatory event on the firm's value should be measured as the total change in returns at the time of the event minus the returns attributable to general market movement. The remaining effect is referred to as an abnormal return. The procedure used in this study to identify abnormal returns is detailed in the following section.

THE MODEL AND DATA

Three methodologies have been used to analyze abnormal returns: the mean-adjusted approach, the market-adjusted approach, and the risk-adjusted capital asset pricing model (CAPM) approach. The CAPM-adjusted approach is used in this study for two reasons. First, simulation results have indicated that the power of test statistics associated with the mean-adjusted method is low under conditions of clustering.^{10,11} Clustering is a condition where firms in the sample are from the same industry as is the case in the current study. Second, the CAPM-adjusted approach is theoretically more appealing than the market-adjusted approach because it does not assume that the comovement of each firm's returns with the market is exactly one for one and that all firms' normal returns are the same on any given day. The market-adjusted approach does not allow the normal return level to vary when an asset's market risk changes. This may be seen by the

fact that in the market-adjusted approach all firms are assumed to have the market return as the normal rate of return on any given day. Thus, the normal rate of return is assumed to be the same for all firms, and no adjustment is made for the specific riskiness of an individual firm.

In the CAPM method, normal returns for each firm are determined by the comovement of a firm's returns with the market rate of return. Normal returns are the returns associated with the component of the firm's risk that cannot be diversified away by holding a diversified portfolio of stocks in the marketplace. Abnormal returns are the returns which can be attributed to the event being examined. As such, abnormal returns are obtained by subtracting normal returns from the actual return for a firm observed in the market.

Use of the CAPM approach requires the estimation of a normal return generating equation for each firm from a pre-event period. In its simplest form, the relationship may be specified as in Eq. (1) and estimated via ordinary least squares (OLS).

$$R_{it} = \alpha_i + \beta_i R_{mt} + e_{it} \quad (1)$$

R_{it} is the actual return for firm i on day t , and R_{mt} is the actual market return on day t , and e_{it} is a random error term. The value $\alpha_i + \beta_i R_{mt}$ represents the normal return for firm i on day t attributable to general market movements.

Following the convention of previous studies and the findings of Brown and Warner,¹⁰⁻¹¹ an equal-weighted index is used as a proxy for the market rate of return in Eq. (1). The market index is calculated using all firms on the New York Stock Exchange (NYSE), approximately 1500 firms, and refers to a portfolio where one share of common stock is held for each firm on the exchange. Even though many stocks are traded on other exchanges, the equal-weighted index is likely to be a good proxy because of its large number of firms and the diversity of firms in the portfolio. The return on the market index of returns for all firms on the NYSE on day t is calculated as

$$R_{mt} = \frac{\sum_{i=1}^{1500} P_{it} - \sum_{i=1}^{1500} P_{it-1} + \sum_{i=1}^{1500} D_{it}}{\sum_{i=1}^{1500} P_{it-1}} \quad (2)$$

where P_{it} equals firm i 's price on day t , and D_{it} is dividend payment on day t .

The actual return for firm i on day t is calculated as the change in the firm's price from day $t - 1$ to day t plus any dividends distributed on day t , all scaled by the price on day $t - 1$

$$R_{it} = \frac{P_{it} - P_{it-1} + D_{it}}{P_{it-1}} \quad (3)$$

where P_{it} is the price of firm i 's stock on day t , and D_{it} is the dividend for firm i on day t .

A potentially serious econometric problem exists when using daily stock price

returns to estimate Eq. (1). Scholes and Williams suggest that an errors in variables problem exists because of nonsynchronous trading.¹² Nonsynchronous trading is a situation where a firm's stock is not continuously traded on an exchange. Specifically, the model previously described assumes that daily stock price returns are computed using closing prices for each stock. Therefore, it is assumed that all returns reflect investor returns for holding the asset for a one-day period while the market is open. In fact, the last trade of the day for a specific firm's stock may occur hours before the close of the market and be reported as the closing price. At other times the reported closing price may reflect a transaction which occurred moments before the close of the market. Thus, the calculated daily return may not reflect the true return for an investor who holds the security for one day; and, in particular, observations on R_{it} and R_{mt} may not be synchronized. Few, if any, securities are so actively traded that prices are recorded continuously. Given that prices are available only at distinct random intervals, "completely accurate calculation of returns over any fixed sequence of periods is virtually impossible."¹² Scholes and Williams suggest an instrumental variable approach for estimation of the return-generating process to solve this problem, where the instrument is an equally weighted moving average of the market rate of return.¹² We follow this approach for estimating Eq. (1), where the specific instrument suggested by Scholes and Williams is given in Eq. (4) below.

$$MAM_t = \frac{R_{mt-1} + R_{mt} + R_{mt+1}}{3} \quad (4)$$

MAM_t is a moving average of the market rate of return and R_{mt-1} , R_{mt} and R_{mt+1} are defined as the equal weighted market return on days $t - 1$, t and $t + 1$, respectively.

For most events in our study, the return-generating model was estimated for each firm using 60 days of data prior to the event. The 60-day period was chosen because it allowed most of the models to be estimated without contamination from prior events. The presence of a prior event in the pre-event period can result in biased estimates of the returns-generating models if the prior event produced abnormally large returns, in absolute value. When 60 days of daily data were not available between event periods, two alternatives for selecting the pre-event period were employed: (a) if at least 45 days of return data were available, the model was estimated based upon the maximum number of returns available between the event periods; (b) if less than 45 days of return data was available, then the period prior to the contaminating event was utilized for model estimation. It was felt that these rules provided a reasonable tradeoff between having sufficient observations to accurately estimate the returns model and the need for model estimation to be based on data reasonably close to the time of the event.

The estimated abnormal return, or return associated with the event that cannot be explained by the return generating process, is specified in Eq. (5) for firm i on day t .

$$AR_{it} = R_{it} - [\hat{\alpha}_i + \hat{\beta}_i R_{mt}] \quad (5)$$

The abnormal return is the actual return minus the return predicted from the return-generating equation.

A three-day event window, spanning the day of the event plus the trading days before and after the event, is used in the analysis. An event window is the time period over which the impact of the informational event is examined. Abnormal returns are commonly examined not only on the day of the event, but also before and after the event to account for possible information leakage or late arrival of information to the market. Information leakage to the market could occur if some market participants are privy to discussions amongst policy makers before public announcements of policy actions. Late arrival of information could also occur. For example, public announcements made near or at the end of the trading day for the stock exchange would not generate market reactions until the next trading day. All of the events examined occurred on trading days so that a three-day abnormal return can be computed as in Eq. (6).

$$TAR_{it} = \sum_{t=t-1}^{t+1} AR_{it} \quad (6)$$

where TAR_{it} is the three-day abnormal return for firm i for event day t . TAR_{it} is then used to determine the impact of an event on firm i .

To determine the overall impact of the event on the industry, we calculate the three-day average abnormal return by summing across the N firms in the industry as in Eq. (7):

$$TAAR_t = \sum_{i=1}^N TAR_{it}/N \quad (7)$$

where $TAAR_t$ is the three-day average abnormal return for the industry for event day t .

To examine whether the event has had a significant value impact upon the industry, a test of the null hypothesis that the three-day average abnormal return across firms equals zero is performed using the test statistic as suggested by Brown and Warner in Eq. (8).¹¹

$$t = TAAR_t / (3\hat{\sigma}^2)^{1/2} \quad (8)$$

where $\hat{\sigma}^2$ is the estimated average daily abnormal return variance over the estimation period.

Letting $t = 1$ represent the day of the event, the variance is calculated as in Eq. (9).

$$\hat{\sigma}^2 = \frac{\sum_{t=-e}^{t=-1} \left(\frac{1}{N} \left(\sum_{i=1}^N AR_{it} - \sum_{t=-e}^{t=-1} \sum_{i=1}^N AR_{it/e} \right) \right)^2}{e - 1} \quad (9)$$

where $-e$ designates the first day of the estimation period. Thus, the variance of the average abnormal return in the pre-event period is being used in the test of the null hypothesis that the mean industry effect is zero.

Daily stock returns were obtained from the CRSP (University of Chicago

Table I. List of Firms in the Sample During Selected Time Periods.

Firm No.	Firm Name	Time Period Data Is Available from CRSP
1	ASARCO	7/2/62–12/31/90
2	E. I. DuPont de Nemours	7/2/62–12/31/90
3	Shell Oil	7/2/62– 6/7/85
4	Monsanto	7/2/62–12/31/90
5	FMC Corporation	7/2/62–12/31/90
6	Dow Chemical	7/2/62–12/31/90
7	Pennwalt Corporation	7/2/62– 9/3/89
8	American Cyanamid	7/2/62–12/31/90
9	Rohm & Haas	7/2/62–12/31/90
10	Stauffer Chemical Company	7/2/62– 3/27/85
11	Canadian Occidental	7/2/62–12/31/90
12	Great Lakes Chemical	7/2/62–12/31/90
13	Imperial Chemical Industries	7/2/62–12/31/90
14	Occidental Petroleum	7/2/62–12/31/90
15	LSB Industries, Inc.	11/4/69–12/31/90
16	Eli Lilly	7/9/70–12/31/90
17	Great American Management and Investment	3/6/72– 3/10/75
18	Alcolac Incorporated	1/10/73– 4/8/81
19	Terra International Industries	10/1/74– 6/15/81
20	Ekco Group	11/18/74–12/31/90
21	Ecolab	12/10/86–12/31/90
22	Ecogen	6/18/87– 1/27/89
23	Montedison	7/16/87–12/31/90

Center for Research in Security Prices) data base for 23 firms that have been, or presently are, producers of pesticides in the United States. These firms are listed in Table I. The firms listed in Table I are all firms listed under the standard industrial code for pesticide producers for which return data was available from CRSP for the 1970–1990 period.

POLICY ANALYSIS

Overview

Regulation of the pesticide industry during the 1970s and 1980s was a complex and litigious process. From the myriad of regulations and pronouncements, it is difficult to determine *a priori* which rules and regulations are likely to have had a significant impact on the financial condition of pesticide producers. The majority of regulatory decrees during this period were motivated by the perception that specific chemicals posed unacceptable risk levels to the safety of the public and/or wildlife. Most regulatory actions have been directed toward reducing risks through the cancellation of a chemical's registration (banning the product) or through controls placed on where and how the chemicals may be applied.

A cross-section of actual and proposed regulations on the pesticide industry is

Table II. Potentially Significant Regulatory Events Affecting the Pesticide Industry.

Chemical	Event No.	Date of Disclosure	Source	Description of the Event
Alachlor	1A	6/11/84	WSJ	Article suggests that the EPA is considering the possibility of restricting use of Alachlor
	1B	1/9/85	PD1	Declaration of concern
	1C	10/8/86	PD2/3	Continued registration with labeling requirements
Aldrin	2A	3/10/70	WSJ	Article suggests that the EPA is considering the possibility of restricting use of Aldrin
	2B	10/18/74	FR	Cancellation of all uses of Aldrin except for termites
Benomyl	3A	12/6/77	PD1	Declaration of concern
	3B		PD2/3	Continued registration with special safety and handling requirements
BHC	4A	10/19/76	PD1	Declaration of concern
	4B	4/30/87	P&TC News	Tolerances resolved and replaced by action levels
Captafol	5A	1/9/85	PD1	Declaration of concern
	5B	4/30/87	FR	Cancellation of all products
Chloranil	6A	1/19/77	FR	Voluntary cancellation
Chlordane	7A	1/27/87	WSJ	Article indicates that the EPA has called for restricting use of chlordane to termite exterminators who are certified or have completed training programs
	7B	11/3/87	FR	Cancellation of all products using chlordane
Chlordimeform	8A	2/8/89	FR	Voluntary cancellation
Chlorobenzilate	9A	5/26/76	PD1	Declaration of concern
	9B	7/11/78	PD2/3	Cancellation of all uses except citrus used in Florida, Texas, California and Arizona
DBCP (dibromo chloropropane)	10A	8/15/77	WSJ	California bans the sale of DBCP which is linked to male sterility
	10B	9/22/77	PD1	Declaration of concern
	10C	9/13/78	PD2/3/4	Voluntary cancellation for uses except pineapple

(continued)

Table II. (Continued)

Chemical	Event No.	Date of Disclosure	Source	Description of the Event
	10D	1/12/84	PD2/3	Cancellation of all remaining uses of DBCP
DDT	11A	7/7/72	FR	Cancellation of all products except for use by US Public Health Service and other Health Service officials
Dinoseb	12A	10/8/86	WSJ	Announcement that the EPA will ban the use of Dinoseb
	12B	10/14/86	FR	Announcement of cancellation of all uses of Dinoseb
EBDCS's	13A	8/10/77	PD1	Declaration of concern
	13B	10/27/82	PD4	Continued registration for all uses with requirement of label amendments
	13C	7/17/87	PD1	Declaration of concern
	13D	12/20/89	PD2/3	Voluntary cancellation or suspension of all EBDC chemicals announced
EDB (Ethylene-dibromide)	14A	12/14/77	PD1	Declaration of concern
	14B	12/10/81	PD2/3	Cancellation and suspension of all uses
Endrin	15A	7/27/76	PD1	Declaration of concern
	15B	11/2/78	PD2/3	Cancellation of all products but one
EPN	16A	9/19/79	PD1	Declaration of concern
	16B	8/31/83	PD4	Voluntary cancellation of all products, no PD2/3 discussion
Lindane	17A	2/17/77	PD1	Declaration of concern
	17B	7/3/80	PD2/3	Continued registration with restricted use classification for commercial uses and label modifications
Silvex/2,4,5-T	18A	8/31/70	WSJ	Concern raised over toxicity chemicals
	18B	4/21/78	PD1	Declaration of concern
	18C	3/15/79	PD2/3	Initial discussion
	18D	7/17/79	PD2/3	Cancellation of all products and uses

(continued)

Table II. (Continued)

Chemical	Event No.	Date of Disclosure	Source	Description of the Event
Toxaphene	19A	5/24/77	WSJ	Article states that the EPA is beginning an inquiry into the safety of Toxaphene
	19B	5/25/77	PD1	Declaration of concern
	19C	11/29/82	PD2/3	Cancellation of all major uses
Superfund	20A	5/1/80	WSJ	A House subcommittee approved a controversial bill that would establish a \$600 superfund drawn partly from private industry
Farmworkers	21A	5/1/73	WSJ	The Labor Department issued temporary standards to protect farmworkers from harmful exposure to pesticides

The abbreviations FR and P&TC News represent the *Federal Register* and the publication *Pesticide and Toxic Chemical News*, respectively. Descriptions of events that coincide with PD2/3 represent the final ruling put into effect by the EPA after this fact finding and preliminary ruling period.^{14,15}

examined. Two sources of events were compiled to generate the list of events found in Table II. Source 1 is Osteen and Szmedra's economic report on agricultural pesticide use trends and policy issues.¹³ In this publication, 22 restrictions on specific chemicals are listed as being representative of the restrictions the EPA has imposed upon pesticide producers during the 1972–1988 period. From this list of 22 chemicals, we were able to identify 19 actions for which the necessary event information was available. These actions range from labeling restrictions and partial cancellations to voluntary cancellations and total cancellations imposed by the EPA.

Source 2 is Dinan, Salassi, and Simon's study in which they list the cancellation of three chemicals, restrictions on the use of a fourth chemical, farm worker protection standards, the Superfund Reauthorization Act, and leaking underground storage tank regulations as past and proposed actions that may have significant economic impacts.¹⁶ Of the regulatory actions, the chemical cancellations and restrictions were also included in Osteen and Szmedra's list of actions. We found appropriate early announcements of farm worker standards and the superfund cleanup bill that could be utilized as informational events in this study. Last, underground storage tank regulations do not appear to be relevant to the pesticide industry *per se*, but may, as Dinan et al. suggest, have a significant impact at the farm level.

Analysis of Events

In its simplest form, the regulatory process for the restriction or cancellation of a pesticide is essentially a three-step process. During this process the EPA pub-

lishes position documents, PDs, in the *Federal Register* concerning its regulatory position relative to pesticides in the special review program.¹⁵ PD1, the first documented issued, is an initial public notification that a pesticide appears to pose an unreasonable risk and solicits comments. A PD2 represents the EPA's decision on the reasonableness of the risk outlined in the PD1. If the PD1 finding of unreasonable risk is not refuted in the PD2, a PD3 is issued in conjunction with the PD2 and states the EPA's preliminary determination of what final legal actions to take. A PD4 is later issued which gives the EPA's final determination to cancel or restrict and becomes law if the affected parties do not pursue a judicial hearing.¹⁷

When an action actually occurs, the PD1 and PD2/3 publications provide risk information to investors in pesticide firms. The PD1, of course, shows that a firm's pesticide is being investigated and that a regulatory change is likely, but may not necessarily occur. The PD2/3 statement, however, indicates that a ruling is highly likely, and it indicates what the nature of this ruling will be. In fact, the PD2/3 statement usually is the culmination of many discussions between the producing firms and the EPA. This ruling is rarely challenged later.¹⁸ Therefore, the PD4 contains little, if any, vital information to investors about the impact on firms.

The previously described regulatory review process is complicated, from the standpoint of investors and their formation of expectations, in two major respects. First, prior to the PD1 statement leakage of information occasionally occurs such that notification of impending EPA action or the concern of independent scientists may alert investors that some action is likely. Therefore, we examined the *Wall Street Journal* (WSJ) index in an attempt to find any such early releases of information. Second, the regulatory process doesn't always follow the pattern described in the above discussion. The most common variation is the issuance of a PD4 after the initial PD1 without the PD2/3 step. This often occurs when firms voluntarily withdraw products from the market. In such a situation the PD4 document provides investors with the information to formulate expectations that would otherwise be provided by the release of the PD2/3. Finally, the EPA may find a chemical to be of such high risk that cancellation, voluntary or involuntary, will occur without a PD4 statement, sometimes preceded by a PD1. In such a situation, the cancellation announcement provides the most important piece of information for investors, because the determination is so rapid that other information sources do not exist.

The events examined in this study were chosen as follows. When the WSJ published an article prior to EPA announcements, the three-day event window (day before, day of, and day after) around the article's publication was examined. Additionally, all PD1 statements of concern were used as events to be examined for the listed chemicals (Table II) and a three-day event window was utilized. When they existed, PD2/3 dates were examined (as perhaps the most important informational announcements) with a three-day event window. Finally, PD4s and cancellation announcements are examined with a three-day event window when PD2/3s were absent.

For each chemical action examined, the most relevant information events and dates are listed in Table II. For example, 1A, 1B, and 1C are informational events associated with the first chemical action examined, the addition of labeling requirements to the chemical Alachlor's packaging. It is anticipated that any announcement suggesting that a chemical will be restricted or banned will have a

negative impact on future cash flows for all firms that have a financial stake in the chemical. It is also anticipated that smaller positive effects may occur for competing firms. Additionally, the regulation of one chemical is likely to increase the probability that similar competing chemicals will be restricted. Logically then, any announcement that delays, reduces, or cancels a possible restriction is likely to have a positive impact on the industry.

Two regulatory actions, in addition to the chemical actions referred to above, appear in Dinan, Salassi and Simons: the establishment of the Superfund clean-up program which includes direct contributions from private industry to a \$600 million cleanup fund for toxic waste sites and the establishment of farmworker protection standards.¹⁶ It is hypothesized that both actions should impact the pesticide industry in a negative way. The Superfund Cleanup Bill would entail direct taxation of all chemical companies, which then would directly reduce the financial resources of all chemical producing firms. The farmworker protection standards will increase the costs to many farmers who employ farmworkers and utilize pesticides, especially among the fruit and vegetable producers. As the effective cost of using pesticides increases farmers may demand less, and such a decrease in demand would negatively affect pesticide producers. To investigate the potential impact of these actions on the pesticide industry, we examine event windows around the first known news of the two possible regulations.

An examination of Tables II and III shows that for 8 of the 19 chemical regulatory actions a significant window was found for an associated informational event. Therefore, nearly one-half of the chemical actions significantly impacted firm value for the industry. Chemical regulatory actions are likely to be found significant if the announcement being examined contains important, reliable, new information and the regulatory action is perceived to significantly affect the earnings of the firms in the industry. A discussion of the significant regulatory events is given below followed by a discussion of the insignificant events.

The events that produced significant abnormal returns (ARs) may be arranged in five categories: (1) events affecting production costs for chemical producers; (2) involuntary limitations on the use of a specific chemical or group of chemical events; (3) a voluntary limitation on use of a chemical; (4) a positive effect on firm value due to regulatory delays; (5) a positive effect which cannot be explained by available information. For all but one of the significant actions, evidence was found that indicated that producers of the chemical were included in the sample of firms used in this study. The existence, or nonexistence, of producing firms was established through a close examination of three sources: *Pesticide Manufacturing and Toxic Materials Control Encyclopedia*, *Chemical Week Pesticides Register*, and *Farm Chemicals Handbook*.¹⁹⁻²¹

Informational events 1B and 3B are declarations of concern for Alachlor and a PD2/3 for Benomyl, respectively. Both of these announcements were part of actions which increased production costs for the producers of Alachlor and Benomyl. The associated action for Alachlor including labeling changes which would increase manufacturing costs. Additionally, because the concern raised in the PD1 was oncogenicity there was a real possibility that the EPA would choose to cancel use of the product. In fact, the province of Ontario, Canada banned use of Alachlor temporarily because of this concern. The action for Benomyl included handling and safety requirements for manufacturers and users of the product. Clearly, such special handling increases producers' costs. When it is

Table III. Estimates of Three-Day Average Abnormal Returns.

Chemical	Event No.	TAAR	<i>t</i> statistic	Same Day as	No. Firms Affected
Alachlor	1A	.00162	.15986		17
	1B	-.02046	-2.09460*	5A	17
	1C	-.00837	-.86432	12A	17
Aldrin/ Dieldrin	2A	-.00373	-.37125		15
	2B	.02556	1.85993		17
Benomyl	3A	.00735	.83999		19
	3B	-.01646	-2.07170*		19
BHC	4A	.00286	.42779		19
	4B	-.00478	-.52648		15
Captafol	5A	-.02046	-2.09460*	1B	17
	5B	.01384	1.49812		16
Chloranil	6A	-.00264	-.30781		19
Chlordane	7A	-.00199	-.21068		15
	7B	.01966	1.30018		17
Chlordimeform	8A	-.008944	-.74667		16
Chlorobenzilate	9A	-.01351	-1.65910		19
	9B	.00101	.11821		19
DBCP (dibromo- chloropropane)	10A	.01032	1.46277		19
	10B	-.00950	-1.38940		19
	10C	.01183	1.38805		19
	10D	-.00572	-.52817		17
DDT	11A	.01010	1.28768		16
Dinoseb	12A	-.00837	-.86432	1C	15
	12B	-.02067	-2.03410*		15
EBDC's	13A	-.00184	-.26392		19
	13B	-.02060	-1.88760		17
	13C	.01497	1.76458		16
	13D	-.01727	-2.04250*		15
EDB (Ethylene- dibromide)	14A	.00078	.8876		19
	14B	-.00225	-2.5555		17
Endrin	15A	.00973	1.18678		19
	15B	.00374	.34436		19
EPN	16A	.02312	2.94434*		19
	16B	.00583	.59032		17

(continued)

Table III. (Continued)

Chemical	Event No.	TAAR	<i>t</i> statistic	Same Day as	No. Firms Affected
Lindane	17A	.00265	.30517		19
	17B	-.02995	-2.38470*		19
Silven/2,4,5-T	18A	.00099	.08498		15
	18B	-.00532	-.77259		19
	18C	-.00405	-.43245		19
	18D	.02275	2.88400*		19
Toxaphene	19A	-.00763	-.97143		19
	19B	-.02411	-3.03020*		19
	19C	.00590	.55607		17
Superfund**	20A	.00352	.29413		19
Farm Worker**	21A	-.00871	-.99928		17

*Significant at .05

**These two events are not chemical actions, but rather proposed policy actions that may impact all firms.

recognized that producers of both products are in the sample of firms examined, it might be expected that these direct costs would negatively impact the industry.

Events 5A, 12B, 17B, and 19B are all informational events for which either the identified chemical was involuntarily cancelled or involuntarily restricted in use by the EPA. These negative impacts are not surprising given that the restrictions and cancellations occurred over the objections of producers and clearly limited the market for established products. It is revealing that the magnitude of the industry-wide effect was large, around 2 to 3% of firm value. Producers of all of the chemicals in question, except Captafol, were, in our sample, an indication that, despite transfers of wealth between firms, the industry-wide impacts were negative when use restrictions were instituted. For Captafol it is difficult to determine whether the significant negative impact is entirely due to its cancellation, because changes in the regulation of Alachlor were occurring concurrently. Because all other significant events found in this study occurred for chemicals for which producers existed in this sample, it is likely that the Captafol result was confounded by the Alachlor action.

Event 13D is an informational event associated with the voluntary cancellation of EBDCs. Event 13D is the only event associated with a voluntary action for which a significant negative impact was found. This result may be explained by two factors. One, the EBDC voluntary action may have been different from other voluntary actions because registrants acted soon after the Alar controversy to avoid adverse publicity. At the time there were rumors that NRDC and "60 Minutes" were going to publicize the EBDC fungicides in much the same way as for Alar. Such publicity could have had a negative impact on the sales of all products for the firms involved. Hence, the potential benefits for the firms was

greater from the voluntary cancellation because of a maintenance of the level of sales for all products. Two, the importance of EBDCs to the registrants can be seen by the fact that they are presented attempting to keep as many uses as possible, including some which were dropped from their labels.

Informational event 18D is one of two events which produced significant positive ARs. At first glance it may seem that this event should have produced a negative effect because it is part of the cancellation of Silvex. This interpretation is incorrect because 18D actually represented a delay in the initial finding to cancel Silvex. The ruling delayed the cancellation date more than five years into the future. Undoubtedly, investors interpreted this to be good news, because it allowed for continued marketing of the pesticide over a reasonable length of time. It is worth noting that ARs from events 18B and 18C were negative, although insignificant. Therefore, other ARs associated with the action are consistent with the positive effect for event 18D.

The positive impact of the final significant event, 16A, is difficult to explain. *A priori*, a voluntary cancellation of EPN would be expected to produce a negative impact on future cash flows. Of course, because this is a voluntary cancellation it might be anticipated that the negative effects would be relatively small or else the action would have been more vigorously opposed. This result is likely to stem from one of two sources. First, perhaps a confounding event occurred on the same day for the chemical industry. To investigate this possibility, we examined the *Wall Street Journal* around the event and found no other events that could produce such an effect. This does not necessarily prove the absence of such an event. Second, the significant abnormal return may have occurred by random chance. Because spurious positive and negative abnormal returns occur with equal probability, we would anticipate such spurious positive ARs in about 1 in 40 tests with a significance level of 5%. In fact, we perform 43 tests of significance for ARs that are related to chemical regulation. Regarding an alternative explanation that the positive AR is simply reflecting a spillover effect within the industry; this is unlikely because there is evidence that a producer of EPN is contained within our sample of firms.

The insignificant informational events may be placed into five categories. These categories include: chemical actions for which no producer firms are in the sample, actions setting cancellation dates by the EPA far into the future, voluntary cancellation or limitation, an action where the chemical was being phased out prior to cancellation, and, finally, the two nonchemical regulatory events.

Actions 4, 7, 8, 9, 11, and their accompanying informational events include a variety of chemical actions including: replacing tolerances by action levels, involuntary cancellations, and voluntary cancellations of products. The common thread connecting these actions is the lack of evidence that producers of the chemicals are included in the sample. The importance of this point cannot be overstated; the insignificant industry impacts of these events suggests that the spillover effects within the industry are relatively small. Specifically, investors do not necessarily re-evaluate downward the value of all agricultural chemical firms when an action is taken against a single chemical or ingredient by the EPA.

Actions 14 and 15 suggest that investors in the chemical industry are sophisticated in their evaluation of the impact of regulations on firm value. The evidence indicates that the timing of involuntary cancellations is as important as the fact that the chemical has been cancelled. The actual cancellation of use for EDB and

Endrin occurred more than seven years after the initial declarations of concern and several years after the initial findings. It is reasonable to assume that the loss of cash inflows to producers, in terms of net present value (NPV), will be much less for these cancellations than for cancellations which occur in a timely fashion. Therefore, such cancellations are much less likely to cause significant value effects.

Actions 6, 8, and 10 are actions which involve the voluntary cancellation of Chloranil, Chlordimeform, and DBCPs. For Chloranil and DBCP, producers of the chemical were found to be in the sample; for Chlordimeform, no evidence of producers in the sample was found. The insignificance of event windows for these chemical actions indicates that investors and analysts view most voluntary cancellations differently than they view involuntary cancellations. The lack of significant value effects may be explained in two ways. One, the EPA tends to give concessions to firms that voluntarily withdraw products from the market. These concessions reduce the firms' financial losses. Two, with most voluntary cancellations producers have weighed the potential costs of opposing the cancellation vs. the potential benefits of continuing production and sales and have concluded that opposing the cancellation is not worthwhile. Hence, the perceived effects of voluntary cancellations are relatively small, and the lack of significance seems to be justified.

Action 2, the involuntary cancellation of Aldrin and the related product Dieldrin, for most uses, did not produce a significant effect on ARs despite the fact that a producer of the chemical exists in our sample. In fact, Shell was responsible for approximately 90% of Aldrin/Dieldrin production during the 1970s.¹⁶ This lack of significance may be explained by two factors. First, total sales of these products was always small relative to the size of Shell Oil Corporation and relative to the pesticide market. Combined sales of Aldrin/Dieldrin reached about 10 million lbs. in 1974, compared with total pesticide use of approximately 600 million lbs.¹⁵ Therefore, the value impact of this involuntary cancellation might be expected to be smaller than for some other chemical actions. Second, the use of Aldrin/Dieldrin was declining prior to the involuntary cancellation. This decline can be attributed to a decrease in the effectiveness of the chemicals in their major use, the control of rootworm in corn production. By 1974, evidence indicates the rootworm population had built up a resistance to Aldrin/Dieldrin.

Actions 20 and 21 are the two nonchemical actions examined. The informational events were announcements in the *Wall Street Journal* notifying the public that regulatory actions were being considered. Neither event produced significant ARs, but the lack of significance occurred for the two events for different reasons.

The approval of a bill by a House subcommittee that would establish a \$600 million Superfund for waste site cleanup to be partly drawn from private industry, event 20A, produced no significant reaction in the market for several reasons. First, the size of the burden on the chemical industry was not made clear by the House subcommittee. Specifically, the government's portion of the fund could either be large or small. Second, any funds raised from the chemical industry would come from the entire chemical industry in the United States, not only from agricultural chemical producers. Thus, any potential burden on agricultural chemical producers would be a fraction of the \$600 million fund. Third, at the introduction of this bill by the subcommittee, investors may be uncertain as to

the likelihood of passage of the bill. Finally, even if investors believe that passage of the bill is highly probable, the timing of the fund formation is unclear. Specifically, any potential delays in fund formation will decrease the NPV of the burden which producers must bear.

Event 21A was the announcement that the Department of Labor was issuing temporary working condition standards to protect farmworkers from harmful exposure to pesticides and that the agency intended to set permanent regulations in the near future. Such an announcement conveyed a great deal of information about a controversial long-term change in policy from the labor department. The fact that no significant abnormal return was produced by this informational event was likely due to the fact that farmworker standards would primarily impact the costs associated with producing agricultural products at the farm level and have only an indirect impact on the demand for pesticides. Such an action does not imply a change in the cost structure of agricultural chemical firms.

SUMMARY AND CONCLUSIONS

This study has examined the economic consequences of regulation on a segment of the pesticide industry that, until now, has been largely overlooked, manufacturers of pesticides. Policymakers, farmers, and consumers should be concerned about the magnitude of these effects, because such effects, if they are industry-wide, may cause reallocation of capital out of the industry. Such reallocation of capital may limit the availability of new products and raise product prices in the future. The economic consequences of pesticide regulation were examined by event study methodology which is relatively new to agribusiness research. Event study methodology utilizes common stock prices to estimate economic impacts on firm value in terms of investors' expectations of future cash flows and risk. Several regulatory actions were found to have significant negative impacts on firm value. The incidence of these effects depends on the type of regulation and the circumstances surrounding the decision to change a regulation.

Six specific conclusions follow from this study. One, the effect of chemical regulation on the pesticide industry can, at times, produce large negative impacts on the value of firms in the pesticide industry. For the events examined, it was found that such impacts could be as high as 3% of the value of firm equity. Two, the results of significance tests indicate that different types of EPA actions will produce different abnormal return impacts on the industry. Specifically, most voluntary cancellations of chemicals were found to produce little effect on the industry, while involuntary cancellations did, at times, produce significant impacts. Therefore, regulators may be able to gauge the degree of impact that a regulation has on the industry by the degree of opposition encountered from the firms being regulated. Three, actions taken by the EPA which require relabeling and/or threaten to restrict use may produce negative impacts to the industry. Four, when the sample examined did not contain the actual manufacturers of a pesticide being regulated, spillover effects from EPA actions to nonproducing firms was minimal. The importance of this result cannot be overstated. It implies that investors do not overreact when regulatory actions occur, and that the regulation or restriction of one chemical has well-focused impacts that are unlikely to significantly influence other segments of the industry. Five, the evidence seems to indicate that discussion of pesticide safety is such an ongoing and

continuous process that announcements that appear in the *Wall Street Journal* regarding particular chemicals tend to have little impact on investors' expectations. This result is somewhat surprising because such announcements are, for investors, often the first source of news regarding the status of firms' products. Finally, evidence presented in this article indicated that passage of the Superfund Cleanup Act and enactment of farmworker standards had little impact on pesticide producers.

REFERENCES

1. C.D. Osteen and F. Kuchler, "Pesticide Regulatory Decisions: Production, Efficiency, Equity, and Interdependence," *Agribusiness*, 7, 307 (1991).
2. J.S. Hughes, W.A. Magat, and W.E. Ricks, "The Economic Consequences of the OSHA Dust Standards: An Analysis of Stock Price Behavior," *Journal of Law and Economics*, 29, 29 (1986).
3. G. Jarrell and S. Peshman, "The Impact of Product Recalls on the Wealth of Sellers," *Journal of Political Economy*, 93, 512 (1985).
4. J. Aharony and I. Swary, "Effects of the 1970 Bank Holding Company Act: Evidence from Capital Markets," *Journal of Finance*, 36, 841 (1981).
5. L.Y. Dann and C.M. James, "An Analysis of the Impact of Deposit Rate Ceilings on the Market Values of the Thrift Institutions," *Journal of Finance*, 37, 1259 (1982).
6. K. Schipper and R. Thompson, "The Impact of Merger-Related Regulations on the Shareholders of Acquiring Firms," *Journal of Accounting Research*, 21, 184 (1983).
7. M.S. Johnson, R.C. Mittelhammer, and D.P. Blayney, "The Impact of Regulation on Shareholder Wealth in the Tobacco Industry: An Event Study Approach," *Agricultural Finance Review*, 51, 21 (1991).
8. J.F. Weston and T.E. Copeland, *Managerial Finance*, The Dryden Press, (1986).
9. J.J. Binder, "Measuring the Effects of Regulation with Stock Price Data," *Rand Journal of Economics*, 16, 167 (1985).
10. S.J. Brown and J.B. Warner, "Using Daily Stock Returns: The Case of Event Studies," *Journal of Financial Economics*, 14, 3 (1985).
11. S.J. Brown and J.B. Warner, "Measuring Security Price Performance," *Journal of Financial Economics*, 8, 205 (1980).
12. M. Scholes and J. Williams, "Estimating Betas from Nonsynchronous Data," *Journal of Financial Economics*, 5, 309 (1977).
13. C.D. Osteen and P.I. Szmedra, "Agricultural Pesticide Use Trends and Policy Issues," USDA, ERS, Report #622, September 1989.
14. Food Chemicals News, "Pesticide and Toxic Chemicals News, Food Chemicals News, Inc., selected issues 1970-1990.
15. United States National Archives, *Federal Register*, Office of the Federal Register, selected issues 1970-1990.
16. T.M. Dinan, M. Salassi, and C. Simons, "Farm-Level Impacts of Recent and Proposed Environmental Regulations on Selected Farm Types," *Agribusiness*, 7, 115 (1991).
17. K.L. Smith, "Special Review and Cancellation Update for Pesticides in the United States January 1970 through December 1990," Unpublished paper, USDA, ARS.
18. C.D. Osteen, Personal communication, USDA, ERS Economist.
19. M. Sittig, *Pesticide Manufacturing and Toxic Materials Control Encyclopedia*, Noyes Corporation, 1980.
20. R.P. Ouellette, *Chemical Week Pesticides Register*, McGraw-Hill, New York, 1977.
21. R.P. Meister, Ed., *Farm Chemicals Handbook*, Meister Publishing Company, selected issues, 1970-1991.